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PERIODIC CLASSIFICATIONS OF THE BIOLOGICAL ELEMENTS

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PERIODIC CLASSIFICATIONS OF THE BIOLOGICAL ELEMENTS.

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The Newlands-Mendeleef Periodic Table can be divided by contour lines into three areas, containing, respectively: (1) elements invariably present in all living organisms, (2) elements associated only with particular species, and (3) elements not shown to be essential for any form of life (Fearon, 1933; Webb & Fearon, 1937; Florkin, 1944; Ruiz, 1945). While this method of classification provides a ground plan for the systematic study of the biological elements, it has the defects common to all short-period systems of tabulation, in that it does not separate sufficiently clearly the main and sub-group elements, and it does not bring into prominence the concept of continuity as well as periodicity.

The first of these defects can be overcome by segregating the elements on a Long-Period Table:

Period	Group																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
I																	1 H	2 He
II	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
III	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 A
IV	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
V	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
VI	55 Ca	56 Ba	57 71	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
VII	87 Fr	88 Ra	89 Ac	90 Th	91 Pa	92 U												

FIG. 1.

Long-Period Classification of the Biological Elements.

This classification emphasises, *inter alia,* the fact that all the transition elements of Period IV (Ti to Cu) are associated with life. These elements are characterised by the possession of variable valencies, catalytic properties, and the ability to form coloured co-ordination complexes.

When the biological elements are segregated on a spiral type of periodic tabulation a periodicity pattern is obtained, the form of which depends on the type of spiral. For purposes of comparison, the elements were segregated on each of six standard types of spiral classification, namely:—

1. A spiral round H, making one complete turn for each long-period, and one turn for each two short-periods (Stoney, 1902; Ryberg, 1914).

2. A spiral round H, making one complete turn for each period (Caswell, 1928).

3. A spiral round H, making one complete turn for each short-period, and two for each long-period (Wells, 1918; Partington, 1926).

4. A spiral round U, making one complete turn for each short-period, and two for each long-period (Tansley, 1921).

5. An elongated spiral round H, each loop of which includes a period ending with a member of the Inert-Gas Family (Clark, 1933; Irwin, 1939).

6. A double spiral, enclosing the main groups and the transition groups, respectively (Nodder, 1920).

None of these types of classification was convenient, as they are complicated, troublesome to construct, and, from a biological aspect, largely irrelevant. Consequently, a simple spiral has been adopted, instead of a logarithmic spiral. The spiral is constructed, with approximate accuracy, by describing semi-circles alternately from two centres situated on the vertical axis of the table. The complete coil of six turns is subdivided by drawing eight diameters and two additional radii, so as to obtain eighteen sectors, each of which corresponds to a group of elements in the Long-Period Table. The arrangement of the elements is similar to that adopted by Irwin (1939), but for the omission of the members of the Lanthanide Group, which he depicts by means of a double-loop between Ce and Hf.

Features of this chart are: (1) The location of the biological elements in a closed area, free from ' islands ' of non-biological elements; (2) the central position of hydrogen, showing its unique status, and indicating by radii its relationship both to the alkali metals and to the halogens; (3) the arrangement whereby the relationship between main and sub-group elements is shown by their being on the same diameter, while the distinction between them is emphasised by their being in opposite sectors.

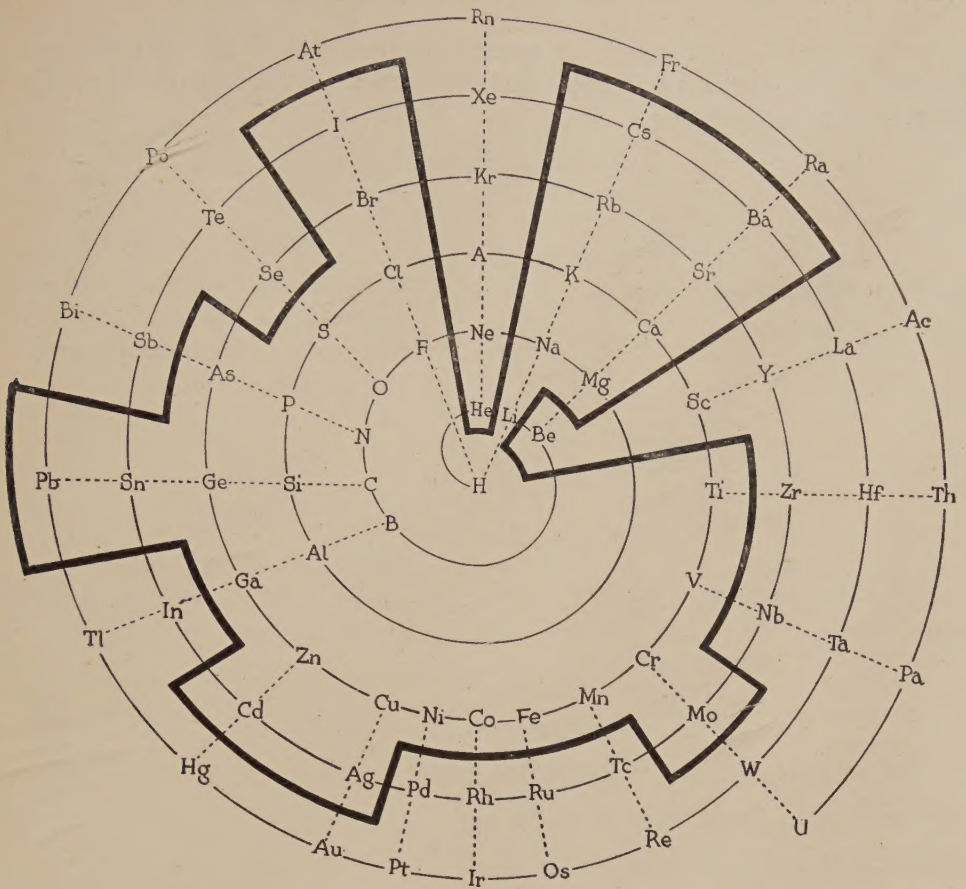

FIG. 2.

Continuous Classification of the Biological Elements.

THE STATUS OF THE BIOLOGICAL ELEMENTS.

In these charts no attempt has been made to disitnguish between *invariable* and *variable* biological elements, as was done in the previous Short-Period Tabulations. This is because the significance of many of the so-called ' trace ' elements is obscure. To have biological status, an element must be of functional value in the maintenance and perpetuation of a species, irrespective of how or where it acts. Three criteria of essentiality have been postulated by Arnon (1948): (a) the life-cycle cannot be completed if the element is absent; (b) the action of the element is specific, and (c) the effect is direct. Nevertheless, an element, of no apparent functional significance in the tissues of an organism: must be regarded as essential if it is required for the maintenance of the external environment of the organism.

In higher animals, especially ruminants, the problem of essentiality is complicated by the demands of what may be termed the alimentary environment, which corresponds to the soil environment of the plant. Thus, a ' trace ' element may owe its importance in animal nutritions to the fact that it is necessary for the growth of

the useful symbiotic organisms now recognised as members of the flora of the normal alimentary tract (Owen, 1947; Ray, 1948). Such a possibility is shown in the following outline classifications:—

BIOLOGICAL ELEMENTS.

Directly Essential.	*Indirectly Essential*
Maintain somatic environment	Maintain the soil environment necessary for the plant, or the alimentary environment necessary for the animal.

Invariable.	*Variable.*
Form part of the structure or metabolic systems of all organisms.	Form part of the structure or special metabolic systems of particular species.

REFERENCES.

ARNON, D. I. (1948), *Nature, Lond.*, **165**, 364.

CASWELL, A. E. (1929), *Phys. Rev.*, **34**, 543.

CLARK, J. D. (1933), *J .Chem. Ed.*, **10**, 675.

FEARON, W. R. (1933), *Sci. Proc. Roy. Dublin Soc.*, **20**, 531.

FLORKIN, M. (1944), *Introduction a la Biochimie générale*, 3rd ed. Paris: Masson.

IRWIN, K. G. (1939), *J. Chem. Ed.*, **16**, 335.

NODDER, C. R. (1920), *Chem. News*, **121**, 269.

PARTINGTON, J. R. (1926), *Chem. News*, **127**, 304.

OWEN, E. C. (1947), *Proc. Nut. Soc.*, **5**, 186.

RAY *et al.* (1948), *J. Animal Sci.*, **7**, 16.

RUIZ, A. S. (1946), *Bioquimica de los Elementos*. Madrid: Instituto "Santiago Ramón y Cajal."

RYBERG, J. R. (1914), *J. Chem. Phys.*, **12**, 585.

STONEY, J. (1902), *Phil. Mag.*, [6] **4**, 411.

TANSLEY, L. B. (1921), *Chem News*, **122**, 121.

WEBB, D. A., and FEARON, W. R. (1937), *Sci. Pro. Roy. Dublin Soc.*, **21**, 487.

WELLS, P. V. (1918), *J. Washington Acad. Sci.*, **8**, 232.